

TABLE I. Sequential treatments of wool fabrics for shrinkage control following a seven-factorial design.

Experiments (Rows)	Step 1: Pretreatment*						Step 2: Treatment
	X1 pH* NaOH (g/L)	X2 Liquor Ratio	X3 time, min.	X4 GA (g/L)	X5 DD (g/L)	X6 H ₂ O ₂ (30% w/v)	X7 Enzyme (% owf)
1	1	1:20	20	1	3	20ml/L	0
2	3	1:20	20	0	0	20ml/L	2
3	1	1:30	20	0	3	0	2
4	3	1:30	20	1	0	0	0
5	1	1:20	40	1	0	0	2
6	3	1:20	40	0	3	0	0
7	1	1:30	40	0	0	20ml/L	0
8	3	1:30	40	1	3	20ml/L	2

*pH range for NaOH: 11.4 to 12.2.

TABLE II. The Physical Properties of Samples Treated in Experiments 1-8 and the Control.

Experiments (Rows)	Weight loss (%)	Δ Thickness (%)	Δ Regain (%)	Shrink- age (%)	Δ WI (%)	Δ YI (%)	Strength (Kg)
1	1.18	31.9	10.2	9.16	-4.01	0.03	20.8
2	22.3	0.17	7.86	5.16	144	-32.5	6.40
3	23.1	7.65	8.52	12.4	64.1	-16.5	4.50
4	1.73	60.0	10.3	30.6	-77.4	20.9	17.3
5	27.0	-1.74	5.37	11.6	72.9	-19.6	4.80
6	1.72	65.6	7.62	35.7	-60.4	15.1	16.9
7	0.56	36.9	10.9	9.27	27.6	-7.40	19.8
8	39.0	-21.4	10.6	-0.86	194.7	-45.9	5.20
control	na	na	na	21.2	na	na	20.6

TABLE III. Importance of Factors from Treatments 1 to 8 of Table I.

Factors	Weight loss (%)	Δ Thick- ness (%)	Δ Regain (%)	Relative Shrink- age (%)	Δ White- ness (%)	Δ Yellow- ness (%)	Strength, Maximum Load (Kg)
X1	12.9	29.6	1.42	28.2	40.4	1.15	-4.10
X2	12.2	-12.7	9.24	-10.2	56.5	-11.9	-2.10
X3	19.9	-20.4	-2.50	-1.60	108	-29.6	-2.30
X4	21.2	-41.6	1.64	-12.0	10.7	-3.35	0.50
X5	13.4	-11.6	2.50	-0.30	27.4	-8.67	-0.90
X6	9.52	-83.9	7.68	-67.6	363	-85.5	8.70
X7	106	-209	-6.72	-56.5	589	-143	-53.9

TABLE IV: Area Shrinkage (%) of samples treated in Table I.

Experiments (Rows)	Initial Shrinkage (%)	Relative Shrinkage (%)	Overall Shrinkage (%)
1	18.3	9.16	25.8
2	10.7	5.16	15.3
3	17.9	12.4	28.1
4	27.7	30.6	49.8
5	16.6	11.6	26.3
6	29.8	35.7	54.9
7	18.5	9.27	26.1
8	5.04	-0.86	4.22
Control	na	21.2	21.2

TABLE V. Treatments without Enzyme, 30°C, 30 minutes.

Sample	NaOH g/L	Triton X-114 2 g/L	GA g/L	DD g/L	H ₂ O ₂ (30% w/v)
61	1	2	1	3	20 ml/l
79	3	2	1	3	20 ml/l
101	Blank: processing conditions without additives				

TABLE VI. Physical Properties of Fabrics Treated According to Treatments in Table V.

Sample	Weight loss (%)	ΔThick-ness (%)	Δ Regain (%)	Relative Shrink-age(%)*	ΔWhite-ness (%)	ΔYellow-ness (%)	Strength (Kg)
61	0.60	15.3	12.30	7.34	69.5	-14.7	21.6
79	0.94	14.6	8.20	2.95	76.6	-18.4	21.4
101	0.08	8.64	-2.34	13.7	37.7	-8.06	18.8

*Initial and overall shrinkages (not shown in Table 6) are as follows: #61 = 7.96% and 14.3%;

#79 = 7.59% and 10.3%; Blank = 6.71% and 19.5%, respectively.

TABLE VII. Enzyme System with PAA/ Triton X-114.

Pretreatment* (#61)	NaOH 1 g/l	Triton X-114 2g/L	GA 1 g/l	DD 3 g/l	H ₂ O ₂ (30 % w/v) 20ml/l
Treatment (#51)			Triton X-114, 1 g/L PAA, 2 % owf No enzyme		
Treatment (#57)			Triton X-114, 1 g/L PAA, 2 % owf 1.5 g/L enzyme		
Treatment (#99)			Triton X-114, 1 g/L PAA, 2 % owf enzyme, 2.0% owf, together with 2% owf Na ₂ SO ₃		

*Pretreatment #61 was used for PAA/ Triton X114 treatments, #51, #57, and #99.

TABLE VIII. Property Values of Fabrics Treated According to Table VII.

Sample	Weight Loss, %	Δ Thick-ness	Δ Regain	Shrink-age, %	Δ White-ness	Δ Yellow-ness	Strength (Kg)
51	-1.43	28.6	-7.86	6.61	76.5	-14.8	23.1
57	0.37	27.1	-9.08	7.73	127	-23.7	21.2
99	5.41	26.0	-11.9	1.16	205	-40.8	15.0
Blank	-1.34	25.9	-12.3	21.9	22.6	-8.34	16.6

Sample	Initial Shrinkage, %	Relative Shrinkage, %	Overall Shrinkage, %
51	10.7	6.61	16.6
57	7.44	7.73	14.6
99	8.88	1.16	9.94
Blank	11.3	21.9	30.7

TABLE IX. Central Composite Design for Enzymatic Treatment.

Run	Na ₂ SO ₃ (% owf)	Enzyme (% owf)	Time (Minutes)
1	0.5	0.5	30
2	0.5	0.5	50
3	0.5	1.5	30
4	0.5	1.5	50
5	1.5	0.5	30
6	1.5	0.5	50
7	1.5	1.5	30
8	1.5	1.5	50
9	0.0	1.0	40
10	2.0	1.0	40
11	1.0	0.0	40
12	1.0	2.0	40
13+	1.0	1.0	20
14+	1.0	1.0	60
15+	1.0	1.0	40
16+	1.0	1.0	40
17+	1.0	1.0	40
18+	1.0	1.0	40
19+	1.0	1.0	40
20+	1.0	1.0	40
*	P	Only pretreatment	
**	B	Blank	
***	C	Control, wash/dry	

*Samples "P" were only pretreated with alkaline peroxide/DD/GA system without further enzymatic treatment for 30 minutes.

**Samples "B" as the blank were pretreated and treated using the same conditions with Run 1-20 but only with water in the treatment bath for 30 minutes.

***Samples "C" were not treated but washed 5 times and air-dried.

+These runs represent the center points for estimating curvature in the construction of the 3D graphs for the central composite design Figure 15.